Policies on environmental and energy saving concerns are driving the local uptake of energy-efficient lighting. LED or solid-state lighting solutions are becoming ever more popular due to their excellent performance levels and shrinking prices.

The lighting industry's need for proper international and local standards to ensure the safety and to measure the performance of LED products is obvious. New products are introduced continually and new standards are constantly called for. Manufacturers claim that the standardisation of performance requirements is an important first step towards fair comparison of luminaires.

The IEC PAS documents list the following, among many other quality criteria to be considered when evaluating manufacturers' claims:

- **Rated input power**: The amount of energy used by a luminaire and its power supply, expressed in watt.
- **Rated luminous flux**: This corresponds to the light emitted by the luminaire and is expressed in lumens.
- **LED luminaire efficacy**: A measure of the initial luminous flux of a luminaire divided by its initial input power, expressed in lumens per watt.
- **Photometric code**: A rating for colour temperature, colour rendering and chromaticity.
- **Rated life of the LED module**: Some of these parameters, rated life in particular, are difficult to measure accurately as the technology is relatively new and the lifetimes of LED products are expected to be much longer than those of other types of lighting system.

The IEC has prepared and published many other safety and performance standards for LED-related controlgear, lamps, modules, luminaires and products. Some of them can be adopted in South Africa easily and published as SANS documents. IEC 62717 and IEC 62722-2-1 cannot, however, be adopted easily as not many testing facilities have the capacity and equipment to conduct the required performance tests successfully and timeously.

The local lighting industry, end-user representatives and other players have therefore founded a working group to address this and to compose a local LED luminaire performance standard which will be available for public comment soon.

**Scope**

This locally-developed standard covers the performance requirements for solid state lighting products including interior lighting, street lighting and floodlighting. It covers LED-based SSL products incorporating control electronics and heat sinks for operation on AC or DC voltage power supplies. It describes the procedures to be followed and precautions to be observed in performing reproducible measurements of:

- **Total luminous flux** or efficiency matrices.
- **Electrical power**.
- **Luminous intensity distribution** and
- **Colour temperature**.

It also describes procedures to be followed and the information to be provided where lifetime claims of operational performance are made. These include:

- **Rated life** (in hours) of the SSL device and the associated rated lumen maintenance ($L_x$).
- **Junction reference points** ($t_s$) of SSL devices that correspond to the rated life.
- **Performance ambient temperature** ($t_q$) for luminaires.
- **Ambient temperature** ($t_a$) for luminaires.
- **Endurance tests**.

**Test methods**

**Photometric measurement**

Strict regulations are prescribed as the photometric values and electrical characteristics of LED products are sensitive to changes in ambient temperature or to air movement. These state that the ambient temperature in which measurements are taken shall be maintained at 25°C ($±$ 2°C).

The LED product under test shall preferably be evaluated in the operating orientation recommended by the manufacturer for an intended use of the LED product. The light emission process of an LED is not affected by orientation. The orientation of an LED product can, however, cause changes in thermal conditions for the...
LEDs used in the product, and the light output may be affected by the orientation of the LED product.

The orientation of the LED product as mounted for measurement shall be reported with the results. Stabilisation and photometric measurements of LED products shall be done in such operating orientation.

Before measurements are taken, the LED product under test shall be operated long enough to reach stabilisation and temperature equilibrium. The time required for stabilisation depends on the type of LED products under test. The stabilisation time typically ranges from 30 minutes (small integrated LED lamps) to two or more hours (large SSL luminaires). Stability is reached when the "maximum-minimum" variation of at least three readings of the light output and electrical power over a period of 30 minutes (taken 15 minutes apart) is less than 0.5%. The stabilisation time used for each LED product shall be recorded.

**Test methods for luminous flux measurements**

**Absolute photometry:**

The total luminous flux measurement (absolute photometry) of LED products is the preferred method and shall be measured with an integrating sphere system or a goniophotometer. The method may be chosen depending on which other measurement quantities (colour, intensity distribution) must be measured, the size of the LED products, and other requirements. It shall be noted that the total flux measurement (absolute measurement) of an LED product will only be a unique measurement if none of the following parameters vary: power consumption, especially the LED current; brightness and colour binning of the LED; colour temperature; the number of LEDs; ambient temperature under which the product is measured, and the optical system.

**Reference measurement:**

If any of these parameters change, another measurement shall be performed. As a result, a reference flux measurement (similar to the relative photometry) of an LED product can still be obtained to reduce the amount of measurements required if the following parameters are the same between the reference product and the associated products: the LED type; the binning of the LED; the colour temperature and thermal management (same shape of reference product etc.). The first step in creating a reference measurement is to place and measure the complete LED reference product inside an integrating sphere system or a goniophotometer.

The reference product must be the most unfavourable version of the product range, e.g. the maximum number of LEDs (highest density) shall be chosen. Only in the case of variable output luminaires shall the current/voltage of the LEDs be set to the prescribed value specified by the vendor, e.g. 350 mA. The first reference measurement shall be taken within 1s so that the junction temperature (T) of the LEDs will not rise higher than 25°C. The next step is to set the LED current/voltage to another value if specified by the vendor. The measurements are repeated until all specified current measurements are concluded. This step is moot in case of non-variable luminaires. The measurements can now be used to calculate ratios between currents, e.g.:

- \( \Phi(T, 25°, 350 \text{ mA}, 20 \text{ LEDs}) = 2000 \text{ lm} \)
- \( \Phi(T, 25°, 500 \text{ mA}, 20 \text{ LEDs}) = 2600 \text{ lm} \)
- \( \Phi(T, 25°, 700 \text{ mA}, 20 \text{ LEDs}) = 3400 \text{ lm} \)

This coefficient will determine the reference total flux of different LED configurations, i.e. varying current or number of LEDs.

**Example**

Luminaire configured to 15 LEDs @ 500 mA:

Single LED flux @ 500 mA:

\[
\Phi(T, 25°, 500 \text{ mA}, 20 \text{ LEDs}) = \frac{2000 \text{ lm}}{20} = 100 \text{ lm/LED}
\]

Total flux of 15 LEDs @ 500 mA:

\[
\Phi(T, 25°, 500 \text{ mA}, 15 \text{ LEDs}) = \frac{2600 \text{ lm}}{15} = 173.33 \text{ lm/LED}
\]

The reference total flux can now be applied for relative measurements as would be done with conventional lamps (e.g. 70 HPS 6000 lm). Where the optical system varies, a new relative measurement shall be conducted.

**Lumen maintenance and stress test**

**Lumen maintenance, lifetime prediction:**

The lifespan of an LED luminaire is the combined effect of gradual light output degradation, mostly caused by electrical component failure. As the typical life of an LED luminaire is long, it is impractical and time-consuming to measure the actual lumen reduction over life. For that reason, lifetime predictions rely on the IES LM-80-08 test data and IES TM-21 lifetime projections of the LED package to determine the expected lumen maintenance of any LED luminaire.

Lumen maintenance of an LED luminaire:

The lumen maintenance measurement relating to the LED light source (i.e. LED package), module and array as defined in the IES LM-80-08 report can be considered as a reference to predict LED luminaire lumen maintenance. LED light source test data shall provide the expected data for at least 25% of rated LED light source lifetime with a minimum of 6000 h (see LM-80-08 test report). This LM-80-08 data shall be used to determine the "useful lifetime" according to the IES TM-21-11 approved method of an LED light source, i.e. a point when the light emitted from an LED light source depreciates to a level where it is no longer considered adequate for a specific application. The data of the LM-80-08 is only relevant if the following LED conditions are met: the LED light source(s) have been tested according to LM-80-08; the LED drive current specified by the luminaire manufacturer is less than or equal to the drive current specified in the LM-80 test report; the LED light source manufacturer prescribes/indicates a temperature measurement point (Ts) on the light source(s); the Ts is accessible to allow temporary attachment of a thermocouple for measurement of the temperature cycling test (access via a temporary opening in the housing, tightly resealed during testing, is allowable). For the hottest LED light source in the luminaire, the temperature measured at the Ts is less than or equal to the temperature specified in the LM-80 test report for the corresponding drive current.

**Endurance testing**

**Temperature cycling test:**

The LED luminaire is placed in a test chamber in which the following cycling sequence will occur:

- At temperature -10°C: luminaire 30 min not energised.
- At temperature -10°C: luminaire 30 min energised.
- Increase temperature to t, +10°C within 1 hour while energised.
- At temperature t, +10°C: luminaire 30 min energised.
- Decrease temperature to -10°C within 1 hour while the luminaire is energised. At -10°C, de-energise and revert back to the first step.

This cycling sequence must be repeated ten times without interruption. Compliance is checked as follows: At the end of the test, the LED luminaire shall operate for
a period of at least 15 minutes and show no physical effects of temperature cycling such as cracks or delaminating.

- **Supply switching test**: The LED product under test shall be switched on and off for 30 s each. The cycle shall be repeated 100 times. At the end of the test, the LED luminaire shall operate for a period of at least 15 min.

- **Accelerated operation life test**: The luminaire shall be operated continuously without switching at test voltage and at a temperature corresponding to \( t_o \) over an operational time of 24 h. Any thermal protection devices that would switch off the LED module or reduce the light output shall be bypassed. At the end of this period, and after cooling down to room temperature, the luminaires shall remain alight for at least 15 min.

**Final report**
The test report shall list all significant data for each LED product tested together with the test results. The report shall also list all pertinent data concerning conditions of testing, type of equipment, LED products and reference standards. Items reported are:

- Date and testing agency.
- Manufacturer’s name and designation of LED product under test.
- Measurement quantities measured (total luminous flux, luminous efficacy, chromaticity coordinates and/or nominal CCT and/or CRI for white light products, input voltage, clarify AC (frequency) or DC current, power and power factor of the LED product).
- Number of hours operated prior to measurement (0 h for rating new products).
- Total operating time of the product for measurements including stabilisation.
- Ambient temperature during measurement.
- Orientation (burning position) of LED product during the test.
- Stabilisation time.
- **Photometric method of instrument used** (spectroradiometer, sphere-spectroradiometer, or goniophotometer).
- **Designation and type of reference standard used** (wattage, lamp type, intensity, distribution type (omnidirectional/directional) and its traceability).
- **Photometric measurement conditions** (diameter of the sphere for sphere measurement; photometric distance for goniophotometer)
- **Measured total luminous flux (lm) (absolute) or reference luminous flux (state parameters) and total lm/input and luminous intensity distribution (if applicable).**
- Equipment used.
- **Deviation from standard operating procedures, if any.**
- Detailed results of tests, e.g. thermal, stress test.

**Acknowledgment**
This article is based on a paper presented at the ninth annual IESSA Conference and AGM and is published here with permission.

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